| ESRF | **Experiment title:** X-ray topography using the three-beam cases of diffraction | **Experiment number:** HS 251 |
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| **Beamline:** ID 19 | **Date of experiment:** from: 29-Jan-97 7:00 to: 03-Feb-97 7:00 | **Date of report:** l-July-97 |
| **Shifts:** 15 | **Local contact(s):** Frank Heyroth | *Received at ESRF:* 2 8 AOUT 1997 |


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Report:

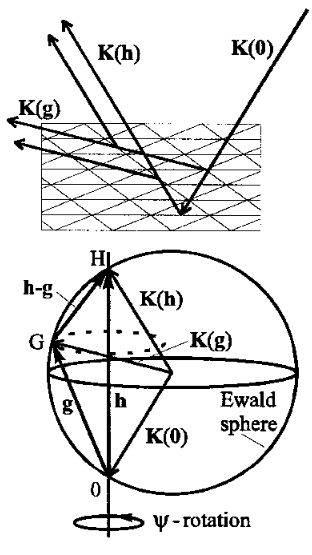



Fig. 1: three-beam case in the direct space (crystal) and in the reciprocal space ( taken from /2/ )

The purpose of this experiment was the first investigation of the topographic contrast of dislocations and stacking faults in the three-beam case of diffraction. In this case, two Bragg reflections h and g are simultaneously excited and three strong wave fields **K(O), K(h), K(g)** exist inside the crystal. The intensity diffracted into the direction of **K(h)** can then be imagined as an interference between the wave diffracted at the lattice planes of **h** (direct wave) and a wave which is diffracted at g and afterwards at **h-g** (Umweg wave). /2/

For the systematical investigation of such a case, a Y-rotation (a rotation around one of the primary reflections e.g. h) was used. The distance of G to the Ewald sphere can then be changed independently from H. For that a complete adjustment and an extension of the horizontal diffractometer at ID19 was necessary.

Afterwards, we have observed the contrast change of dislocations and stacking faults with plane wave topography in several three-beam cases. It was of special interest to investigate such geometries, where the defect is out of contrast in one of the main reflections, e.g. in **h.**

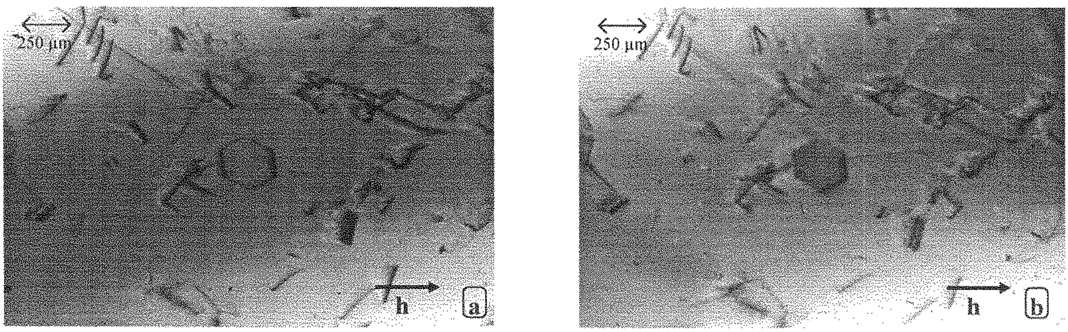
In the first part of our beam time we had some technical problems with the counter and so precise ψ - scans could not be done for all the reflections.

Figure 2, gives an example of the contrast change for a stacking fault in the three-beam case of the interference. In the two-beam case, (Fig. 2a) the hexagonal stacking fault has no contrast. Only the surrounded partial dislocation is visible. Under the exact excited three-beam conditions the interference with the Umweg-wave gives additional intensity (Fig. 2b). In this case the effective structure factor for the stacking fault image in the 422 topograph is modified so that the phase shift of the wave when going through the stacking fault is no longer zero (like in the 422 two-beam case). Exact calculations are in preparation.

A comparable behaviour could be observed for the studied dislocations. In addition a complete change of the fine contrast was found. (In the available beam time it was only possible to investigate 60° dislocations in silicon with a Burgers vector $\mathbf{b} = \frac{a}{2}\langle 110 \rangle$.) In the last shifts we started with section topographs.

As one result we can say: Our topographic experiments have shown that the defect contrast can be "transfered" from the g wave by means of the Umweg-wave (h - g) into the h wave. There is no simple vector superposition $\mathbf{h} \cdot \mathbf{b} = ((\mathbf{h} - g) + g)\,\mathbf{b}$ for the contrast.

For a general statement, further experiments are urgently necessary. The systematic investigation of the change in the topographic contrast for different reflection geometries is proposed in the new application for beam time.



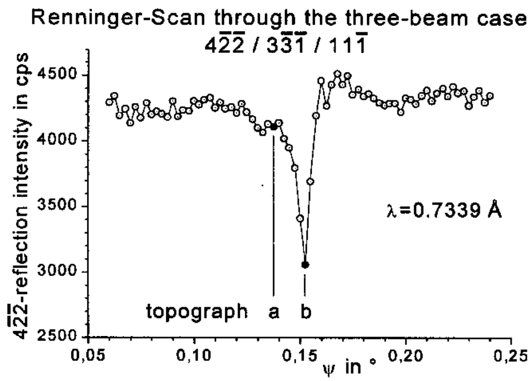




Fig. 2: double crystal topographs of a stacking fault (fault vector $\mathbf{b} = \frac{a}{3}[111]$) in a silicon crystal outside (a) and inside (b) the three-beam condition:

$$\mathbf{h} = (4\bar{2}\bar{2}); \mathbf{g} = (3\bar{3}\bar{1}); \mathbf{h} - \mathbf{g} = (11\bar{1})$$

On the left the corresponding Renninger-($\psi$ -) scan along the maximum of the $4\bar{2}\bar{2}$ rocking curve is shown. The topographs in Fig. 2 were taken at the marked positions (a) and (b).

**references**

/1/ Höche, H.R.; Heyroth, F. & Eisenschmidt, C. (1997) „X-Ray topography using three-beam interferences“ ECM-17 Lisboa

/2/ Hümmer, K., Weckert, E. (1996). „Determination of reflection phases by three-beam diffraction“ in „X-Ray and Neutron Dynamical Diffraction: Theory and Applications“ edited by Authier, A., Lagomarsino, S., Tanner, B.K., Plenum Press, New York, 1996, 345-367.